Speech physiology, speech perception, and acoustic phonetics

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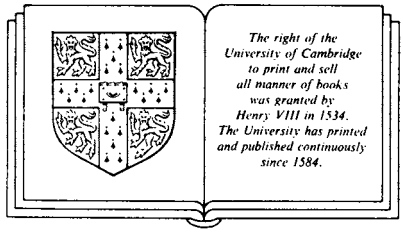

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Introduction

The study of language and the sounds of speech can be traced back at least to the Greek and Sanskrit grammarians of the third and fourth centuries BC. The explicit study of speech science began in the eighteenth century when Ferrein (1741) attempted to explain how the vocal cords produced phonation. Ferrein's studies were not an isolated event. Kratzenstein (1780) and von Kempelen (1791) attempted to explain how the vowels and consonants of human speech were produced by synthesizing sounds using artificial "talking machines." There indeed may have been earlier attempts at constructing talking machines; La Mettrie (1747) discusses some of these early attempts, but we lack detailed records. By the mid nineteenth century Müller (1848) had formulated the source–filter theory of speech production, which is consistent with the most recent data and still guides research on human speech as well as the vocal communications of other animals. Although Müller's theory was further developed later in the nineteenth century, particularly by Hermann (1894), the modern period of speech science is really quite recent, dating back to the late 1930s, where devices like the sound spectrograph, and techniques like high-speed photography, cineradiography, and electromyography made new data available. Quantitative studies like those of Chiba and Kajiyama (1941), Joos (1948), Peterson and Barney (1952), Stevens and House (1955), and Fant (1960) refined and tested the traditional phonetic theories of the nineteenth century and provided the framework for comprehensive, biologically-oriented studies of speech production, speech perception, and phonetics. The advent and general availability of digital computers made quantitative modeling studies possible. New techniques for speech synthesis and psychoacoustic experiments have made it possible to explore the fundamental properties of human speech.

We are beginning to understand how human speech is produced, how it is perceived, and how the physiological properties of the vocal tract and the neural mechanisms of the brain contribute to speech processing. We also are beginning to understand how human language and human speech evolved and how other animals communicate. The development of speech and language in infants and children is being explored, and new possibilities are opening for the

diagnosis and amelioration of various speech pathologies.

The focus of this introduction to speech physiology and acoustic phonetics is thus to provide a background to the "new" speech science. An understanding of the acoustics of speech, the physiology of speech production, and the special factors that are involved in the perception of speech is a prerequisite for further study of the pathologies of speech production or the neurological impairment of either speech production or speech perception. It is also necessary for the development of quantitative, predictive phonetic and phonological studies. While linguists have studied the sound structure of language, exploring the processes of sound change and the structure of sound systems in language, it is the study of speech science which may provide the explanations for *why* sounds change in the way they do and *why* the sound systems of natural language are structured in the way that they are. This introduction is no substitute for a traditional phonetics text, focused on teaching people how to make transcriptions of various languages and dialects. The training techniques that phoneticians use are not included in this book because our objective is to understand the biological mechanisms that are the basis not only of human speech, but also of vocal communication in many other animals.

Readers who have a good background in high-school mathematics should have little difficulty in following the discussions of the acoustics of speech production or the source–filter theory of speech production. Readers who have a more advanced background may be able to skim appropriate chapters.

Although readers may find this book a useful reference source, its primary function is pedagogic. It should be viewed as an introduction to the physiology of speech and acoustic phonetics. Many current problems are not discussed in detail, and the advanced reader may be familiar with topics that have been omitted. Everyone, however, should encounter new material and indeed should note that speech science is still a frontier with many gaps in our knowledge yet to be filled. It is becoming apparent that human speech is an integral part of human linguistic ability. The biological bases of human speech are complex and appear to follow from the Darwinian process of natural selection acting over at least 250 000 years to yield specialized anatomical and neural mechanisms in *Homo sapiens* (Lieberman, 1984). The gaps in our knowledge concerning the biological bases of human speech thus reflect the difficulties inherent in understanding the nature of language and human cognition of which speech forms a crucial part.